Contract Number W9132T-04-C-0017

ReliOn, Inc.

Final Project Report

Proton Exchange Membrane (PEM) Fuel Cell Demonstration Of Domestically Produced PEM Fuel Cells in Military Facilities

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement CERL-BAA-FY03

Gray Army Air Field Instrument Landing Systems
Ft. Lewis Army Base
Tacoma, Washington

August 31, 2006

Executive Summary

The CERL fuel cell installation at Ft. Lewis near Tacoma, Washington was one of three ReliOn demonstration sites funded under the BAA-FY03 program (CERL3). The other ReliOn demonstration sites are at Ft. Rucker, Alabama (3 units at 1 kW each and 1 unit at 2 kW) and Gabreski Air National Guard Base, Long Island, New York (1 unit at 4 kW).

This project tested the reliability of the ReliOn backup power solution for U.S. Military Air Traffic Control and Landing Systems (ATCALS). The fuel cell systems were connected to the 24V DC bus at each site. The fuel cell systems were configured to monitor the commercial AC power grid as well as the status of the existing DC backup batteries at each site. Upon loss or failure of either power source, the fuel cells were designed to start automatically to provide up to 48 kWh of continuous run power to critical equipment at each site. In addition to providing continuous protection from a primary power failure, the installation was designed to simulate a 1-hour power failure in the AC grid each day. Data were collected concerning start-up times, power availability, shutdown capability, system efficiencies, load following, and the effects of varying environmental conditions. If the system failed to start up properly or provide required power to the load this was noted in the logs as a failure and counts against the target 90% reliability and availability of the system.

Through the end of the 1-year test program, there were a total of 1,569 starts and 1,565.5 hours of run time. In addition to the daily test runs, the ReliOn Fuel Cell systems at these sites maintained critical equipment functionality over 10 primary power outages totaling 15 hours during the demonstration period. According to CERL reporting requirements, overall reliability and availability calculations in this project have been based on total system performance, including special test equipment (computers, modems, PLC controllers) that is not part of ReliOn's commercial fuel cell product line. Availability calculations are also impacted by missed fuel deliveries if vendor scheduling or site access issues result in depletion of fuel reserves. Such incidents have been very infrequent over the 1-year demonstration period. When they have occurred, the fuel cells started on command but were unable to sustain energy delivery to the load, resulting in automatic reconnection of the site rectifier. On this basis, cumulative reliability for the demonstration program at Ft. Lewis was 98.6% and cumulative availability was 98.4 percent. When fuel supply interruptions or test computer malfunctions are removed from the calculations, reliability and availability of the commercial fuel cell equipment were both at 99.7% for the entire 1-year demonstration period.

At the conclusion of the demonstration test program, the fuel cell systems were removed from each site and relocated to a warehouse facility at Ft. Lewis for possible future deployment at the base.

Table of Contents

1.0 Descriptive Title

A demonstration of modular proton exchange membrane (PEM) fuel cells to serve as back up power for mission critical loads – ILS and other communication systems.

2.0 Name, Address and Related Company Information

ReliOn, Inc.	DUNS #: 137264193
15913 East Euclid	CAGE Code: 3K7Y7
Spokane, WA 99216	TIN: 912191190
Tel:	(509) 228-6500
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ReliOn, Inc., a privately held, small business, headquartered in Spokane, Washington, manufactures and markets proton exchange membrane (PEM) fuel cell products based on a unique and patented modular design. The company's current focus is on the sale and installation of highly reliable backup power solutions for critical applications within the telecom, utility and government/military markets.

ReliOn's offering helps customers increase network reliability while reducing overall equipment life-cycle costs in stationary, low power applications, typically requiring 200 watts to 5 kilowatts. Our air-cooled, self-hydrating fuel cells are highly reliable because we require only a minimal balance of plant and are able to bypass potential failure points.

ReliOn, formerly Avista Labs, has been developing, demonstrating and marketing PEM fuel cell technology since 1995.

3.0 Production Capability of the Manufacturer

ReliOn, Inc., as described above, was the manufacturer and integrator of the primary products that comprised the backup power solution. These products incorporate the I-1000™, 1kW fuel cell systems, and the Outdoor Enclosure System which is designed to house the fuel cells, hydrogen fuel and fuel delivery system. ReliOn was responsible for installation and commissioning of the backup power solutions and performed all maintenance requirements via company applications engineers.

The I-1000™ Fuel Cell models and Outdoor Enclosure Systems are commercially available and offered under full warranty terms. ReliOn is currently (mid-2006) releasing its next generation fuel cell systems—the T-1000™ and T-2000™ products—which are substantially based on the I-1000™ product line. Until the end of 2004, ReliOn produced the I-1000™ product line through its contract manufacturer, Celestica, with production facilities in Fort Collins, Colorado. The fuel cell systems installed in this project were manufactured by Celestica. ReliOn currently has two contract manufacturers—Servatron producing circuit boards and control system subassemblies, and Logan Industries for final fuel cell assembly and integration into the Outdoor Enclosure system. Both of these firms are located within a 3 mile radius of ReliOn headquarters in Spokane, Washington, allowing easy interface and rapid problem solving. Production totaled approximately 500 I-1000™ fuel cells and 250 Outdoor Enclosure systems in 2005. With the release of the T-1000™ and T-2000™ products, these outputs are on track to double in 2006.

ReliOn's fuel cells are made from common materials using mature manufacturing processes in injection molded plastic, sheet metal fabrication and printed circuit board assembly. The membrane electrode assemblies (MEA) are purchased through a supply agreement with 3M.

4.0 Principal Investigator(s)

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Mr. Russell Neff
Application Engineer
ReliOn
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5.0 Authorized Negotiator(s)

Mr. Frank A. Ignazzitto
Vice President, Government Sales
ReliOn
703-431-4858
509-228-6506
fignazzitto@relion-inc.com

6.0 Past Relevant Performance Information

ReliOn currently (mid-2006) has more than 200 fuel cell systems installed and operational in commercial applications covering 4 continents. Our fuel cell systems and backup power solutions have achieved numerous safety and performance certifications including; CSA, CE and NEBS Level III (telecom).

ReliOn's experience is inclusive of the following installations:

- **The Federal Aviation Administration;**
  - Palwaukee, IL, Radio Transmitter Receiver, December, 2003
  - Swinns Valley, WI, Microwave, June, 2004
  - Wakeman, OH, Microwave, August, 2004
  - Fargo, ND, RCAG, September, 2004
  - Average turn-key cost was approximately $35,000
  - Contacts: Mr. Stanley Lee, General Engineer, 847-294-8457; stanley.lee@faa.gov
    Mr. Steve Aldridge, Environmental Engineer, 952-997-9264; steve.aldridge@faa.gov

- **The Bureau of Reclamation;**
  - Loveland, CO, Microwave, October, 2003
  - System cost was approximately $15,000
  - Contact: Mr. Nathan Myers, Electrical Engineer, 303-445-2633
    nmyers@do.usbr.gov

- **The States of Maryland and Ohio;**
  - 2 Sites in MD, 4 Sites in OH
  - E-911 radio equipment, August 2003 to October, 2004
  - Average turn-key cost was approximately $30,000 (no outdoor enclosure)
  - Contact: Mr. George Milne, COO, havePOWER, 202-299-0506
    gmilne@havepower.com

7.0 Host Facility Information

Fort Lewis, part of Forces Command, is the home of I Corps. I Corps was initially activated at Neufchateau, France on January 15 1918, and has participated in more campaigns than any other corps. I Corps is the most decorated corps in the active Army and is the only corps ever to receive the U.S. Presidential Unit Citation. The Corps' primary focus is Pacific Rim. As a result, I Corps has a close, ongoing relationship with Pacific Command. A noteworthy monument to the U.S. Army 4th Infantry Division, stationed at Ft. Lewis between 1956 and 1966, is just inside the main gate and is shown in Figure 1.

The project at Ft. Lewis Army Base is located around Gray Army Airfield and consists of four individual installation sites – Localizer, Glide Slope, Middle Marker beacon and Outer Marker beacon. The Localizer and Glide Slope are located on Gray Army Airfield, within the property of Ft. Lewis. The Middle Marker is located outside of Gray Army Airfield but still within Ft. Lewis and the Outer Marker is gated in an area located approximately 1 mile north of Ft. Lewis on a property known as Goddard Woods.

Key contact personnel at the host site are as follows:

Mr. William Perez
ATC Maintenance Supervisor
Gray Army Airfield
Voice: (253) 967-2980
Fax: (253) 967-3237
Email: perezb@lewis.army.mil

The installation site locations are shown in Figure 2. Each site utilizes one ReliOn I-1000 (1kW) fuel cell system as a source of backup power for instrument landing system (ILS) equipment. Photographs of each site are shown in Figure 3.

Figure 1. Statue at Ft. Lewis Honoring the 4th Infantry Division
"To The Steadfast And Loyal Infantrymen Of The Famous Fourth"

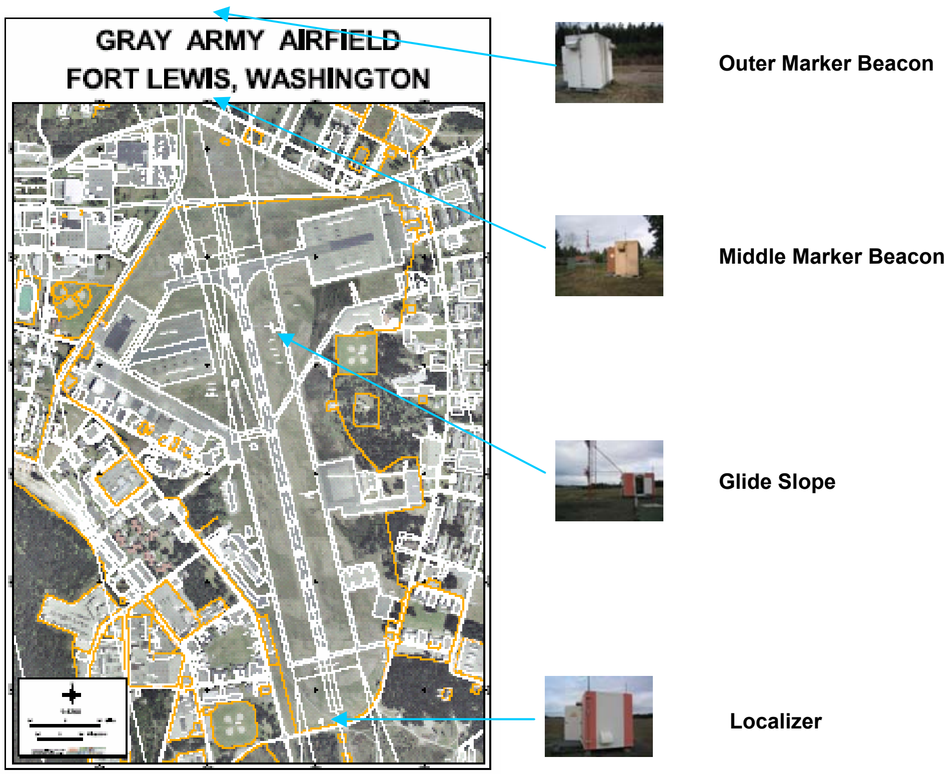

Figure 2. Gray Army Air Field Instrument Landing System Locations

Figure 3. Gray Army Airfield Instrument Landing System Shelters

8.0 Fuel Cell Installation

The ReliOn Fuel Cell Outdoor Enclosure is a self-contained, turn-key system that is delivered to the site ready to set on the concrete pad and wire in to AC and DC circuits and connect to a local analogue telephone line. The Scope of Work supplied by ReliOn to the general contractor for installation of the fuel cell systems at Ft. Lewis including all power wiring and signal and control interconnection is given in Appendix 1. Installation drawings for the four fuel cell installation sites at Ft. Lewis are included in Appendix 2.

Site work for the four installations at Ft. Lewis began during the third week of May 2004. All equipment was installed by June 15 allowing ReliOn engineers to complete final signal and control connections and initiate system commissioning. All fuel systems were started and tested between June 29 and July 1. The Localizer, Glide Slope, and Middle Marker sites were fully commissioned on July 16 and the 1-year test program was started on that date. Installed ReliOn fuel cell systems at the Localizer, Glide Slope, and Middle Marker are shown in Figure 4. Poor data communication with the Outer Marker site delayed the start of the 1-year test program until the local telephone service provider was able to troubleshoot and repair the line. The 1-year test program at the Outer Marker was started on August 17, 2004.

Localizer

Glide Slope

Middle Marker Beacon

Figure 4. ReliOn Fuel Cell Installations at Localizer, Glide Slope, and Middle Marker

The daily test runs were scheduled to occur during normal business hours over periods of representative equipment loads. This also allowed ease of scheduling if host site personnel, ReliOn staff, and guests wished to observe the tests. The data from the laptop computer in each enclosure was downloaded to a server at ReliOn by remote dial-up after each system test run. The data logging computer also included an alarm notification utility that automatically dialed preprogrammed phone numbers to notify ReliOn personnel of any alarm condition. One analogue POTS telephone line was used for remote monitoring at each site. The tests at Ft. Lewis were timed as shown in Table 1.

Table 1. Ft. Lewis CERL Test Schedule

Site No.	Site Name	Local Test Time (Pacific)
3-1	Ft. Lewis Localizer	9:00 AM
3-2	Ft. Lewis Glide Slope	10:30 AM
3-3	Ft. Lewis Middle Marker	12:00 PM
3-4	Ft. Lewis Outer Marker	1:30 PM

The test run simulated a power outage everyday for a 60-minute time period in order to test the availability of the fuel cell system. A programmable logic controller (PLC) was installed with each system to simulate the grid outage by opening a relay to cut AC power to the ILS equipment. The PLC also monitored the run status of the fuel cells and reconnected AC power to the ILS equipment in the event of any type of operational failure that could have jeopardized the protected equipment. The fuel cells were connected directly to the 24 Volt DC bus at each site. Once a day, AC power to the ILS equipment was disconnected. At the same time, the fuel cells started and provided power to the loads for 1 hour. At the end of the test period, AC power was restored and the fuel cells shut down.

In addition to the daily test, the fuel cell systems were configured to monitor the commercial AC power grid as well as the status of the existing DC backup batteries at each site. Upon loss or failure of either power source, the fuel cells started automatically to provide up to 48 kWh of continuous run power to critical equipment at each site.

9.0 Electrical System

At each of the four sites, the fuel cell systems were installed in a grid-independent mode with the only interconnection being an AC sensing circuit in the fuel cell enclosure. A block diagram showing relationship between the fuel cell system and existing ILS equipment is shown in Figure 5.

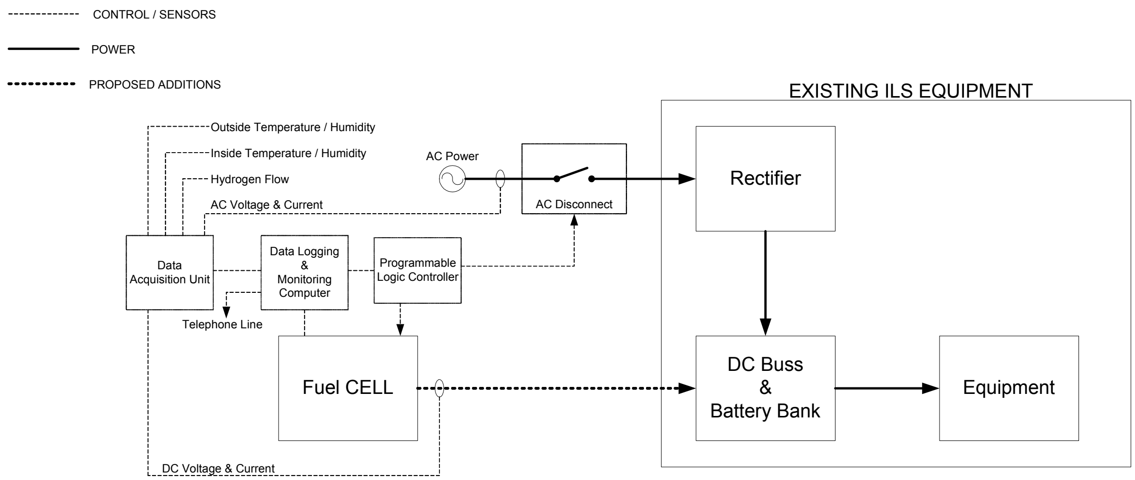

Figure 5. Functional Block Diagram Showing Fuel Cell System Interconnection with Existing Equipment

All systems operated in a standby/ready mode to provide backup power for critical DC equipment in the event of a loss of primary AC power. The following connections were been established at each site:

- Electrical Requirements:
  - One 20 Amp circuit at each site for AC sense and the enclosure heater. The heater was designed to keep the environment around the fuel cell above freezing to facilitate startup. Once the fuel cell is running, it utilizes its own heat for operation.
  - AC disconnect relay between AC power and rectifier
  - DC connection between fuel cell system and DC bus in customer's equipment cabinet
  - The PLC, data monitoring equipment, and data logging computer were powered from the 24 VDC terminals inside the enclosure. This ensured that the data continue to be recorded during any extended AC outage.
- Telephone Lines
  - One phone line required per site for data monitoring
  - One computer with dial-up capability at each site

– See Appendix 2 for site specific connections

10.0 Thermal Recovery System

Because ReliOn's PEM fuel cells operate at low temperatures, the system was not a cogeneration system. The system was installed in an outdoor enclosure designed to maintain the internal temperature within the operating range of the I-1000™.

11.0 Data Acquisition System

The load at each ILS shelter was between 50 watts and 200 watts. A Programmable Logic Controller (PLC) was used to start the fuel cell once a day for a test period of one hour. The PLC also energized a relay at the same time to disconnect AC power from the shelter rectifier.

A data acquisition system was also included in each enclosure to monitor and record the following:

- Inside temperature
- Inside Humidity
- Outside Temperature
- Outside Humidity
- AC Voltage at the site
- AC current at the shelter rectifier
- DC Voltage at the shelter DC bus
- DC current from the fuel cell
- Hydrogen fuel flow

All vital information from the I-1000™ fuel cell was also monitored and recorded. The data-logging computer was connected to the data acquisition module and fuel cell via Ethernet. The data-logging computer was configured to dial a designated ReliOn personnel cell phone during any of the following alarm conditions:

- Loss of AC Voltage
- Low DC Voltage (Less than 23 VDC)
- Hydrogen Sensor Alarm
- Fuel Cell Major Alarm
- Hydrogen Bank Empty
- Enclosure Fan Alarm

The system was also be configured to start automatically during a loss of the AC grid and in the event the facility DC bus voltage fell below a pre-determined limit (low voltage startup). The low voltage startup protected the ILS equipment in case of a facility rectifier/charger failure or a fault in the battery string. The low voltage start threshold was set at 23 VDC for the ILS systems at Ft. Lewis.

Daily run data for each site was available to host and US Army Corps of Engineers personnel through a password protected website. Monthly run data summaries through the entire project demonstration period are included in Appendix 3.

12.0 Fuel Supply System

The fuel cell systems operated with industrial grade hydrogen gas. Compressed gas is the easiest and most commercially available source of industrial grade hydrogen. The outdoor enclosure includes two locked hydrogen storage and delivery systems which ensured that the compressed hydrogen cylinders were protected and accessible only to authorized personnel. A sketch of the hydrogen compartments is shown in Figure 6.

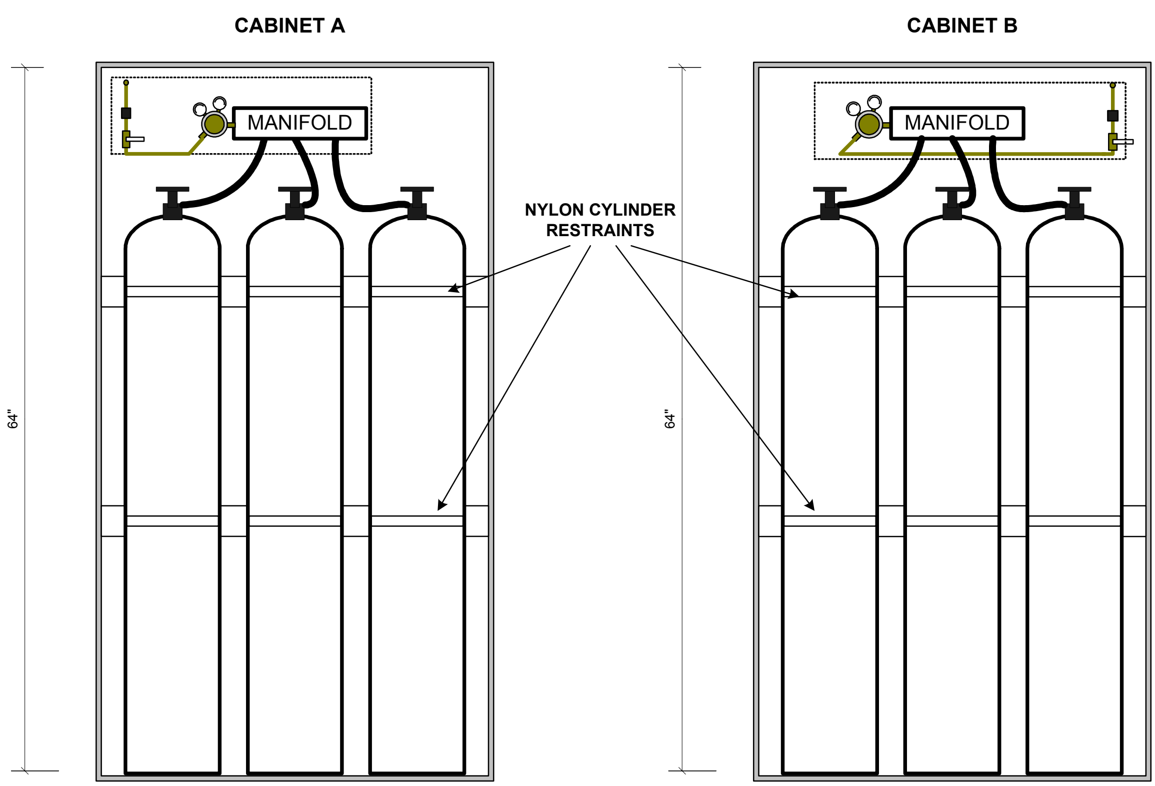

Figure 6. Hydrogen Fuel Compartments

The cylinders were typically size 300 (nominal 285 cu. ft or 8071 liter gas capacity at STP conditions), although size 200 could also be accommodated. Full cylinders were delivered with gas pressure at between 2000 and 2200 psig. Each of two hydrogen storage compartments contained three (3) cylinders directly connected into a high pressure manifold. The manifolds were each equipped with pressure switches and a regulator to reduce the gas pressure for delivery to the fuel cell. The pressure switches were monitored by the data logging computer which sent alarms to the ReliOn personnel when the gas pressure fell to a pre-determined level. Hydrogen gas deliveries were made to each site by the local distributor for Airgas, Inc. at approximately 6 week intervals. Additional deliveries were scheduled as required to accommodate unplanned AC grid outages and extended test periods.

The optimal setting for the pressure regulators to the fuel cell was 40-50 psig. By adjusting the regulated pressures so that one bay is 5-10 psig higher than the other side, hydrogen was withdrawn from the higher pressure side until those cylinders were exhausted. The system then drew hydrogen from the other side allowing time to order and replace the depleted cylinders.

The fuel supply system and refill logistics generally performed well in the project, apart from a fuel outage due to a missed hydrogen delivery in October 2004 at the Localizer site. This resulted in an overall loss of 9 starts and 9 hours of run time for that month. In addition there were two failures of the PLC control system and/or the data-logging computer which caused a further loss of 6 starts and 6 hours of run time over the 1-year test program. When fuel supply interruptions and special test equipment issues are removed from the calculations, reliability and availability of the commercial fuel cell equipment were both at 99.7% over the entire 1-year demonstration period.

13.0 Installation Costs

Table 2 shows a breakdown of project costs thru January 2005 for the ReliOn PEM fuel cell backup power demonstration project at Ft. Lewis, Washington. The total project proposed cost including ReliOn's profit and cost share for the entire contract was $363,781.64. Of this amount, $135,006 was allocated for the Ft. Lewis sites.

Table 2. Project Costs for Contract Number W9132T-04-C-0017 (Ft. Lewis Site)

Task 1: Fuel Cell Power Plant **Direct Labor**		Plan			Actual Through End of Project
Staff	Activity	Units	Unit Cost	Total Cost	
Applications Engineer	Training			$300	$300
Equipment					
I-1000 Fuel Cell		4	$8,050	$32,200	$32,200
Enclosure w/2 Fuel Wings		4	$5,950	$23,800	$23,800
Task 1 Subtotal				**$56,300**	**$56,300**

Task 2: Installation **General/Electrical Contractor**	Plan			Actual Through End of Project
General Contractor			$3,200	$3,200
Electrical Contractor			$6,400	$6,400
Materials & Expenses				
Crane/Fork Lift			$2,000	$2,000
Telecommunications			$20,000	$20,000
Task 2 Subtotal			**$31,600**	**$31,600**

Task 3: Performance Monitoring **Direct Labor**		Plan			Actual Through End of Project
Staff	Activity	Units	Unit Cost	Total Cost	
Applications Engineer	Monitoring & Data Management			$2,600	$504
Principal Investigator	Monitoring & Data Management			$1,200	$3,380
Task 3 Subtotal				**$3,800**	**$3,884**

Task 4: Maintenance **Direct Labor**		Plan			Actual Through End of Project
Staff	Activity	Units	Unit Cost	Total Cost	
Applications Engineer	On Site Training			$300	$300
Applications Engineer	Remote & Site Maintenance			$1,200	$1,200
Principal Investigator	Remote & Site Maintenance			$0	$200
Task 4 Subtotal				**$1,500**	**$1,700**

Task 5: Project Management & Reporting **Direct Labor**		Plan			Actual Through End of Project
Staff	Activity	Units	Unit Cost	Total Cost	
Project Manager	Management, Reporting, Meetings			$1,200	$1,575
Principal Investigator	Management, Reporting, Meetings			$800	$700
	Initial Project Description			$600	$600
	Monthly Status Report			$300	$555
	Midpoint Report			$600	$600
	Final Report			$600	$600
Task 5 Subtotal				**$4,100**	**$4,630**

Table 2 (Continued).
Project Costs for Contract Number W9132T-04-C-0017 (Ft. Lewis Site)

Task 6: Travel				Plan	Actual Through End of Project
Managerial Travel				$367	$367
Technical Travel-Installation				$2,591	$5,733
Technical Travel-Maintenance				$2,016	$2,100
Technical Travel-Decommissioning				$1,496	$1,496
Task 6 Subtotal				**$6,470**	**$9,696**

Task 7: Decommissioning/Site Restoration **Direct Labor**		Plan			Actual Through End of Project
Staff	Activity	Units	Unit Cost	Total Cost	
Applications Engineer	Site Work			$0	$2,481
Principal Investigator	Site Work			$0	$0
General/Electrical Contractor					
Labor				$6,400	$3,280
Materials & Expenses					
				$4,000	$1,000
Task 7 Subtotal				**$10,400**	**$6,761**

Task 8: Other Costs **Equipment & Expenses**			Plan	Actual Through End of Project
Hydrogen Fuel			$12,200	$10,450
Electrical Equipment			$10,000	$10,000
Task 8 Subtotal			**$22,200**	**$20,450**

Ft. Lewis Total	**$136,370**	**$135,021**
Profit (10%)	$13,637	$13,502
Ft. Lewis Total Project Cost	**$150,007**	**$148,523**
ReliOn Cost Share (10%)	($15,001)	($13,517)
Ft. Lewis Total Project Billing	**$135,006**	**$135,006**

14.0 Milestones/Improvements

Through the end of the 1-year test program, there were a total of 1,569 starts and 1,565.5 hours of run time. In addition to the daily test runs, the ReliOn Fuel Cell systems at these sites maintained critical equipment functionality over 10 primary power outages totaling 15 hours during the demonstration period.

15.0 Decommissioning/Removal/Site Restoration

Pre Installation pictures can be seen in section 7 of this document. Upon completion of the successful test program, the host (Ft. Lewis) requested that the fuel cell systems and all wiring and underground conduit at each of the four sites be removed. The host requested that the concrete pads be left in place for possible future use by the fort and chose to transfer ownership of the fuel cell systems to their affiliate ‘Anteon’ with the contact being Kevin Visscher, Program Manager for Energy Public Works, Ft. Lewis. Mr. Visscher arranged for his department to truck the fuel cell systems to his warehouse for possible use in the future. ReliOn released all interest in the project materials at that time. Conduit penetrations at each structure wall were restored to the satisfaction of the Ft. Lewis personnel. This work was completed at the site by ReliOn Application Engineers during the week of February 6, 2006. The below pictures represent a typical site decommissioning and site restoration at Ft. Lewis. The below pictures depicts the “Outer Marker” site.

16.0 Conclusions/Summary

Through the end of the 1-year test program, there were 1569 starts and 1565.5 hours of run time (cumulative for all four sites). Both reliability (Actual Starts/Attempted Starts) and availability (Actual Run Time /Scheduled Run Time) for the reporting period for all four sites at Ft. Lewis were at 100 percent. Cumulative reliability for the demonstration program to date for all four sites at Ft. Lewis was 98.6 percent. Cumulative availability for the demonstration program to date at Ft. Lewis was 98.4 percent. When fuel supply interruptions or test computer malfunctions are removed from the calculations, reliability and availability of the commercial fuel cell equipment were both at 99.7% for the entire 1-year demonstration period.

Consistent with the reporting criteria established under the CERL program, all system outages, regardless of origin, have been reported in the monthly data summaries and accounted for in the reliability and availability calculations for the system. Over the duration of the test program, there were 1,569 successful fuel cell system starts for 1,592 attempts during the scheduled test periods for all four Ft. Lewis sites. Of the 23 failed attempts, only 4 can be traced to an issue with the commercial fuel cell product. This occurred on January 17, 2005 at the Glide Slope when the internal hydrogen detector in the fuel cell registered a concentration approaching 7500 ppm (approximately 18% of the lower flammability limit for hydrogen in air) causing the system to initiate a safety shutdown. The faulty cartridge was replaced during an unscheduled maintenance visit on January 21 which allowed the fuel cell system to resume normal operation. A failure analysis inspection revealed a manufacturing flaw in the cartridge which resulted in a leaking hydrogen seal. The remaining 19 unsuccessful test runs were due to faults in the research instrumentation to control and record the tests, poor telecommunication links to the sites, or an interruption in fuel delivery.

Appendix

1) ReliOn Fuel Cell System Site Preparation Contractor Scope of Work
2) Ft. Lewis Fuel Cell Installation Drawings
3) Monthly Performance Data
4) Commissioning Procedures for the I-1000™ Fuel Cell & Outdoor Enclosure System

Appendix 2

Ft. Lewis Fuel Cell Installation Drawings

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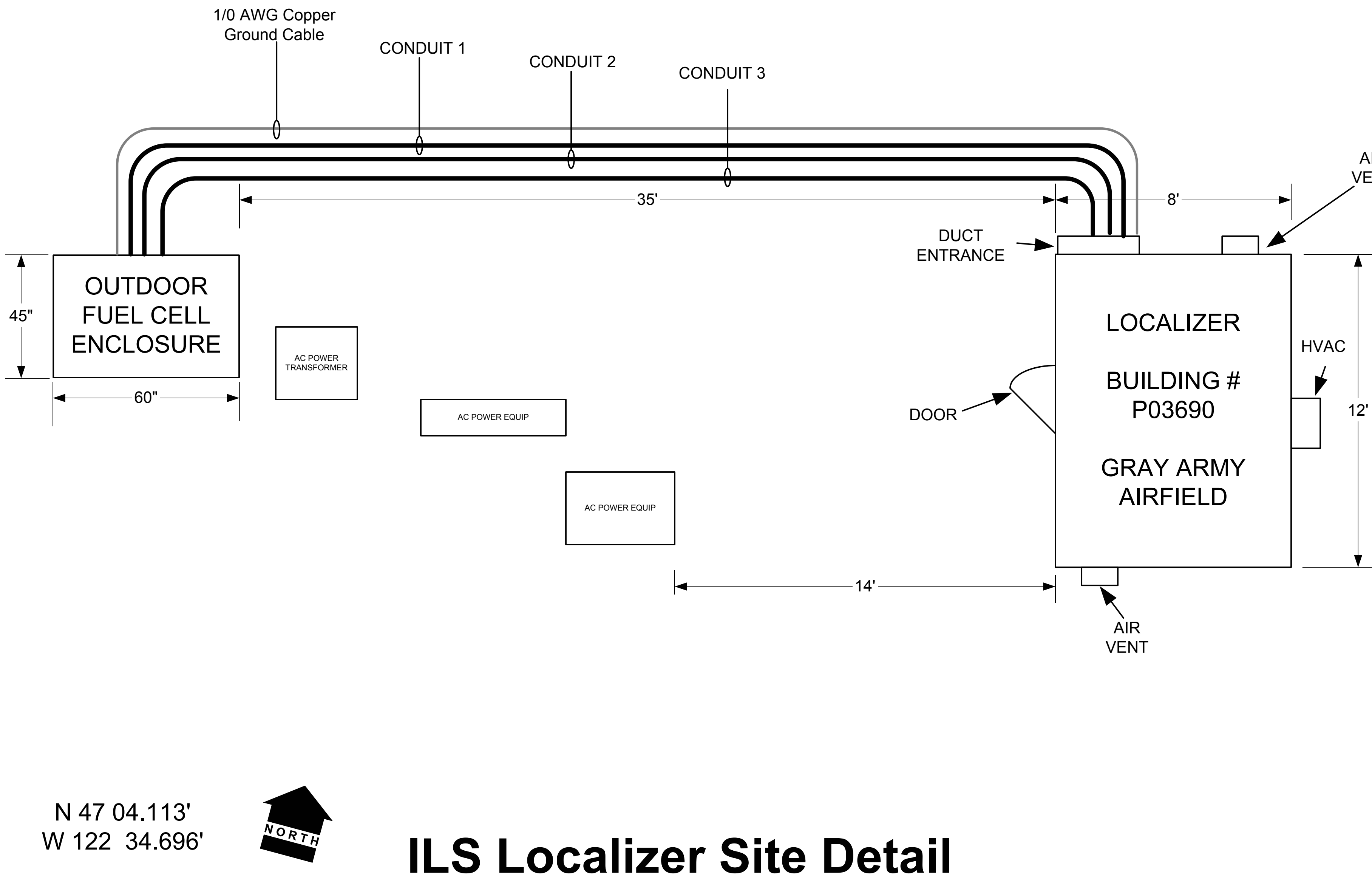

ILS Localizer Site Detail

Avista Labs
15913 East Euclid Avenue
Spokane, Washington 99216
Telephone: 509-228-6500
Facsimile: 509-228-6510

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FUEL CELL INSTALLATION		LARRY HAGER
PROJECT	DATE	PAGE
FORT LEWIS ILS	3/26/2004	1 OF 7

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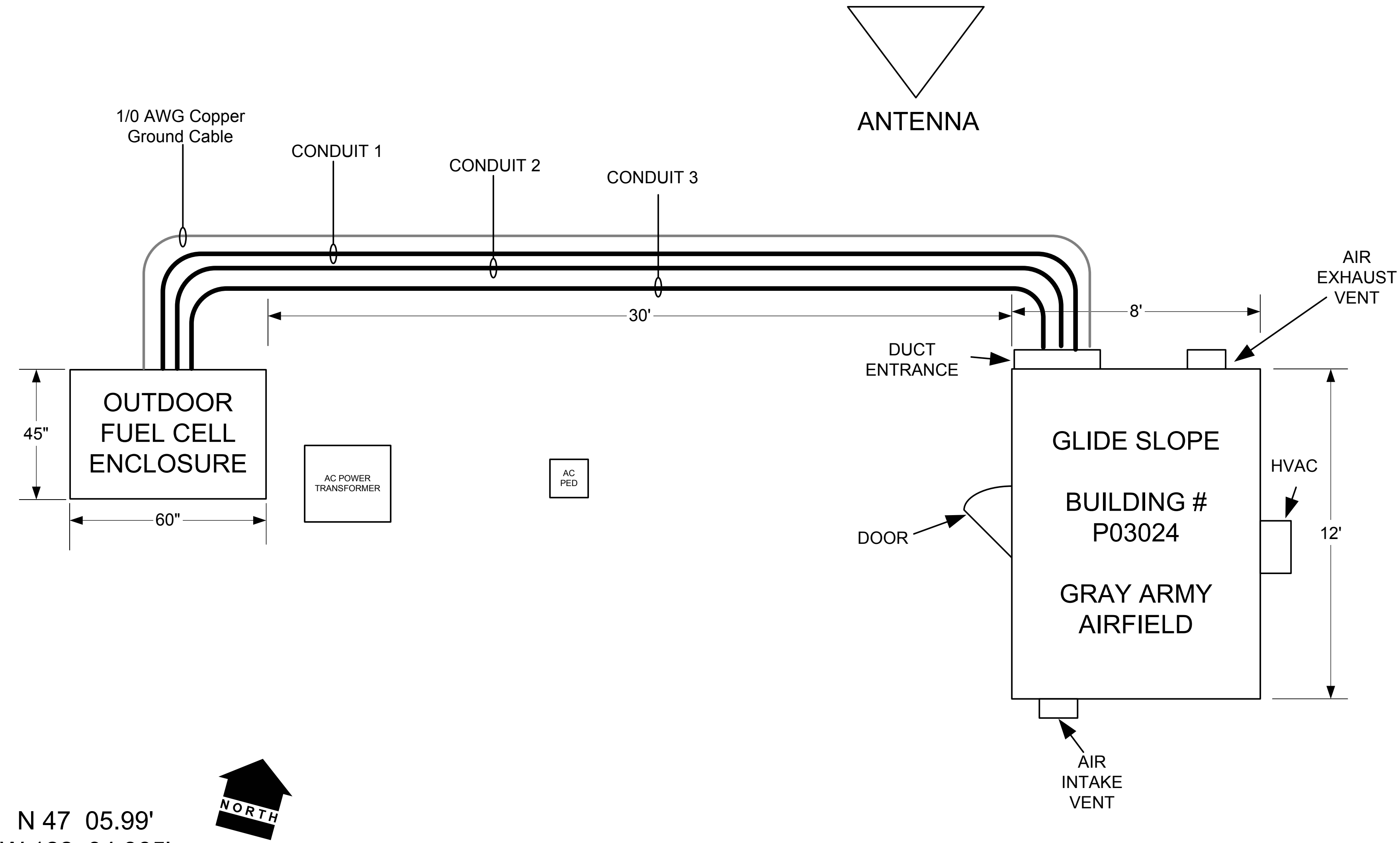

N 47 05.99'
W 122 34.865'

ILS Glide Slope Site Detail

AVISTA Labs
15913 East Euclid Avenue
Spokane, Washington 99216
Telephone: 509-228-6500
Facsimile: 509-228-6510

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PROJECT	DATE	PAGE
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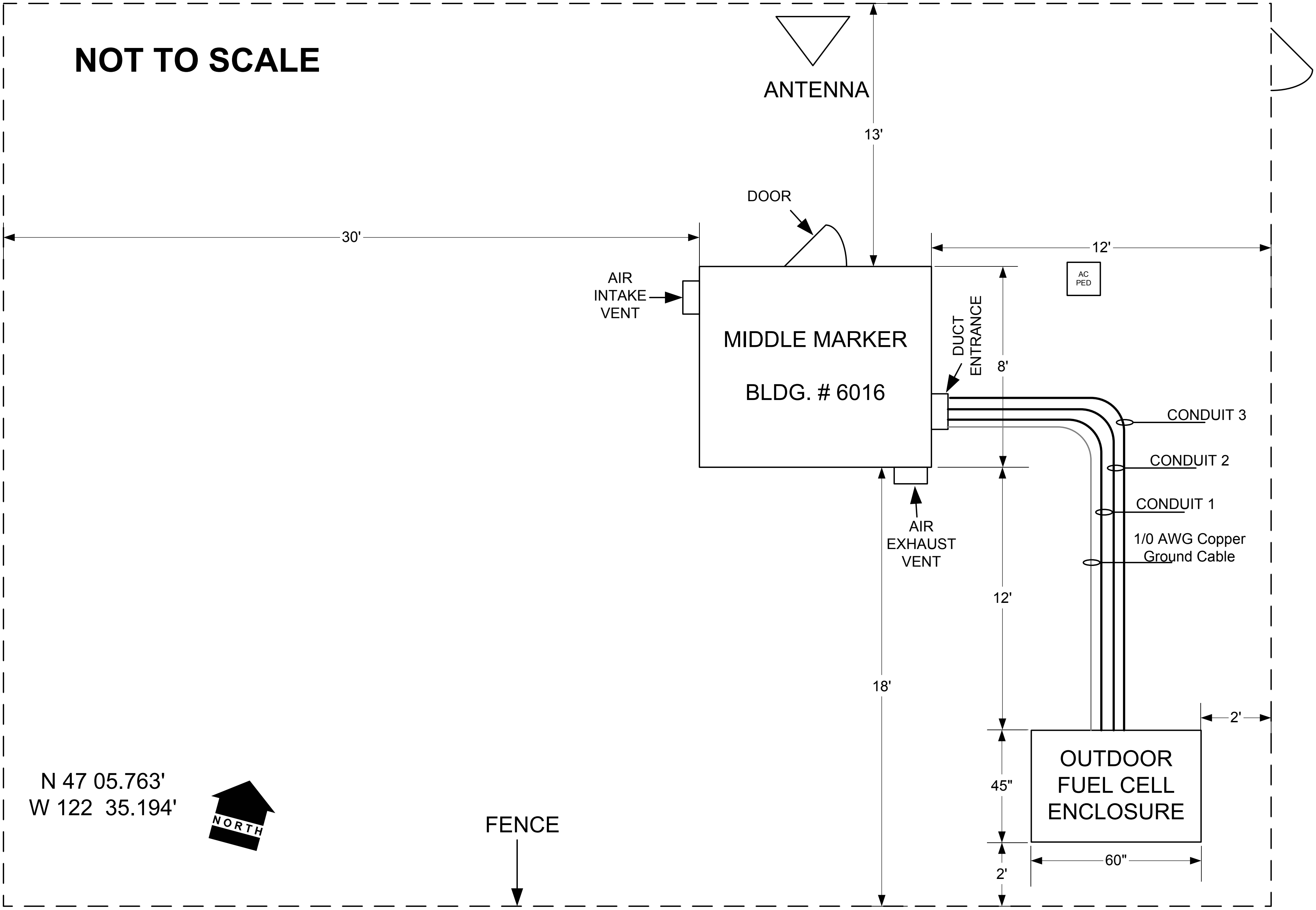

ILS Middle Maker Site Detail

AVISTA Labs
15913 East Euclid Avenue
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Telephone: 509-228-6500
Facsimile: 509-228-6510

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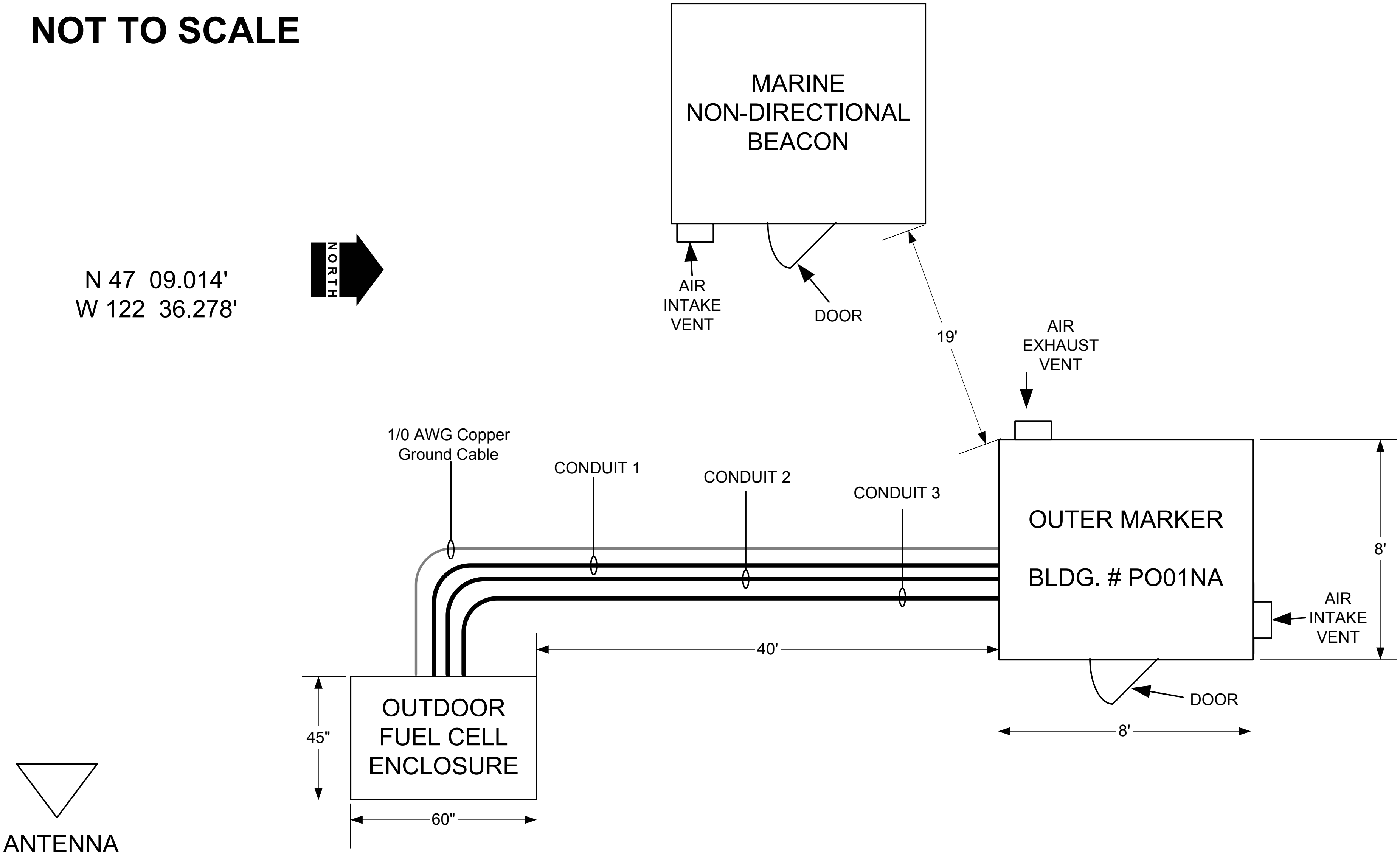

ILS Outer Maker Site Detail

AVISTA Labs
15913 East Euclid Avenue
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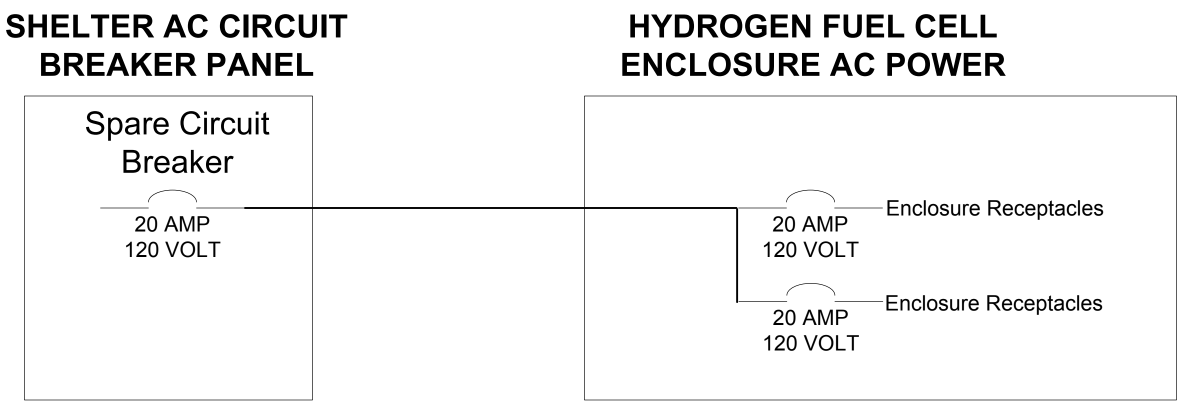
PROJECT: FORT LEWIS ILS	DATE: 3/26/2004	PAGE: 4 OF 7



AC Power Wiring Detail

Notes:

1. Connect the AC power wires to the spare 20 Amp circuit breaker in the shelter circuit breaker panel.

2. Connect the AC power wires to the two 20 Amp circuit breakers in the fuel cell enclosure

AVISTA Labs
15913 East Euclid Avenue
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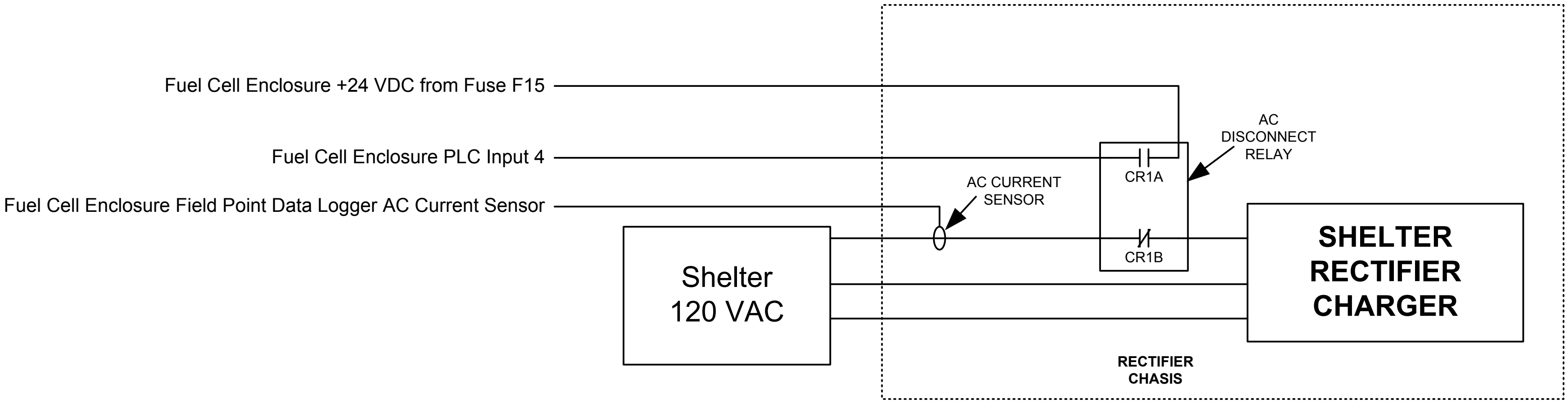
PROJECT: FORT LEWIS ILS	DATE: 3/26/2004	PAGE: 5 OF 7



AC Power Disconnect Relay Detail

Notes:

1. Disconnect AC power to shelter rectifier and install AC current sensor and AC disconnect relay in line.

2. ReliOn applications engineer will connect control wiring for the AC disconnect relay and current

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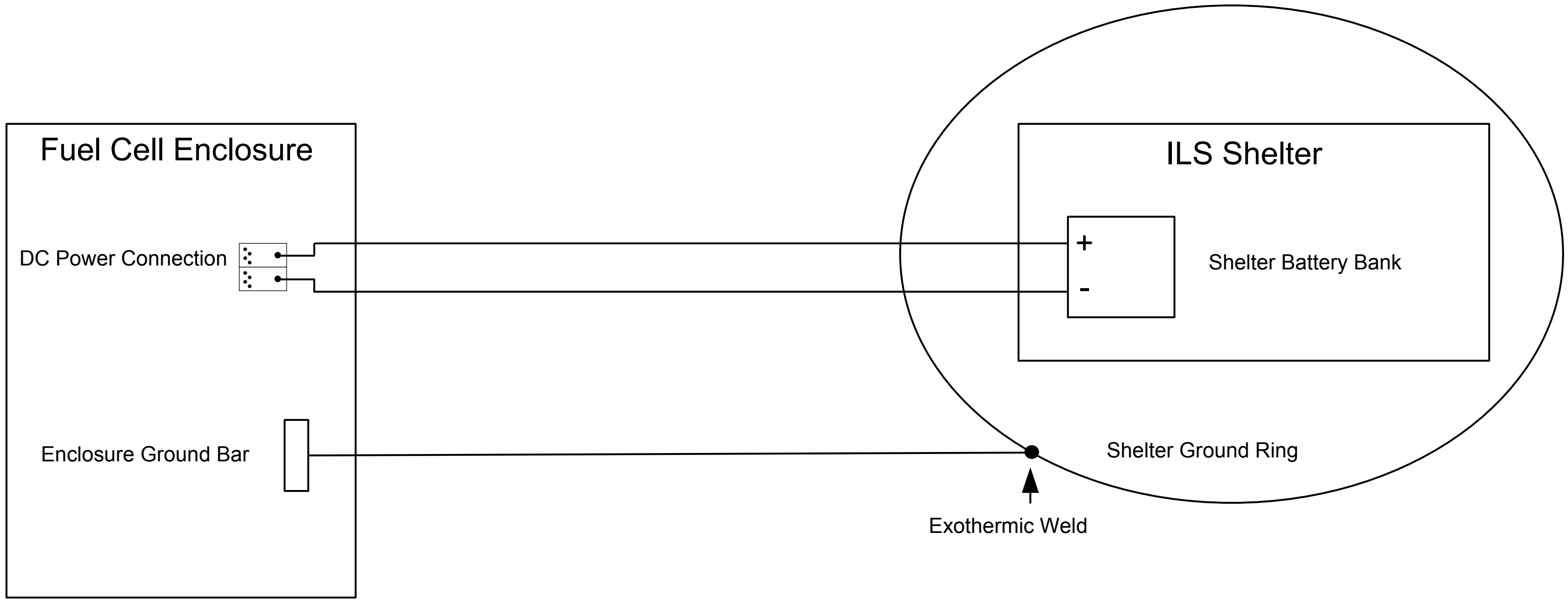

DC Power Wiring Detail

Notes:

1. Connect DC power wires at the fuel cell enclosure first. Connect the DC power wires to the ILS Shelter battery bank after the wires have been connected at the fuel cell enclosure

2. Connect the ground cable to the fuel cell enclosure ground bar. Connect the ground cable to the ILS Shelter ground ring using an exothermic weld

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